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SERIE: FISKERI · BIND XI

NR. 4. P. HEEGAARD: INVESTIGATIONS ON THE BREEDING SEASON AND THE QUANTITIES OF EGGS OF THE FOOD-FISHES OF THE KATTEGAT AND THE NORTHERN BELT SEA. 1929—1941.

KØBENHAVN
C. A. REITZELS FORLAG
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1947

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SERIE: FISKERI · BIND XI · NR. 4 · 1947

INVESTIGATIONS ON THE BREEDING SEASON AND THE QUANTITIES OF EGGS OF THE FOOD-FISHES OF THE KATTEGAT AND THE NORTHERN BELT SEA. 1929—1941

BY

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On the initiative of "Kommissionen for Danmarks Fiskeri- og Havundersøgelser" a number of plankton samples were taken for a series of years from three Danish light-vessels for the purpose of establishing more exactly the time at which the different food-fishes spawn in our inner waters and the outer factors that influence this time. These samples were taken with Hensen nets in vertical hauls from bottom to surface once a week during the years between 1929 and 1941. The Hensen net applied had a mouth of 67 cm. in diameter thus covering an area of $^1/_3$ m^2. On account of the many fish eggs that are spawned early in the year two hauls were made immediately after each other during the first four months of the year; for the rest of the year only single hauls were made.

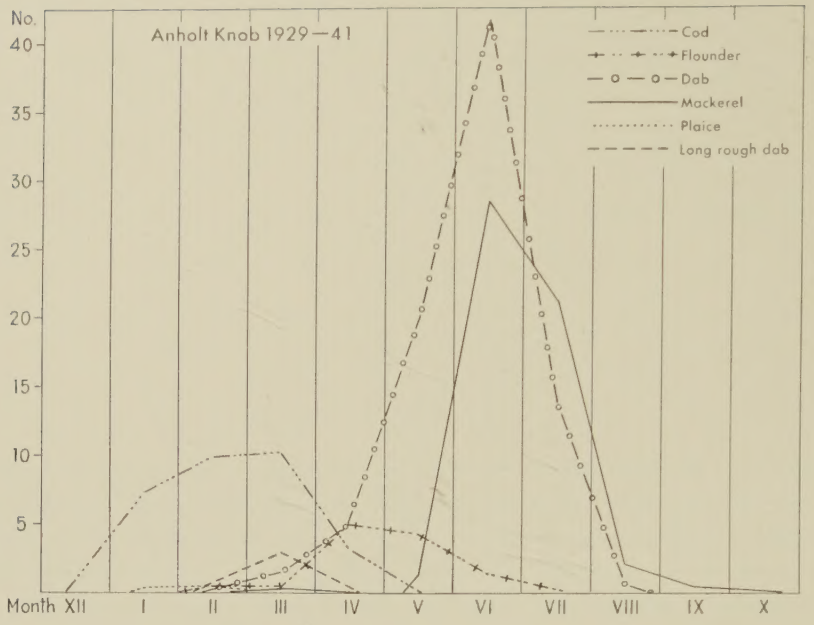
These samples were made from the three light-vessels of Anholt Knob in the central Kattegat, Schultz Grund in the southwestern Kattegat and Halskov Rev in the Great Belt. The staffs of the light-vessels made the hauls, preserved the samples in 4 per cent. formalin and sent them to the Biological Station, the best thanks of which are due to the personnel of the three light-vessels for their valuable help.

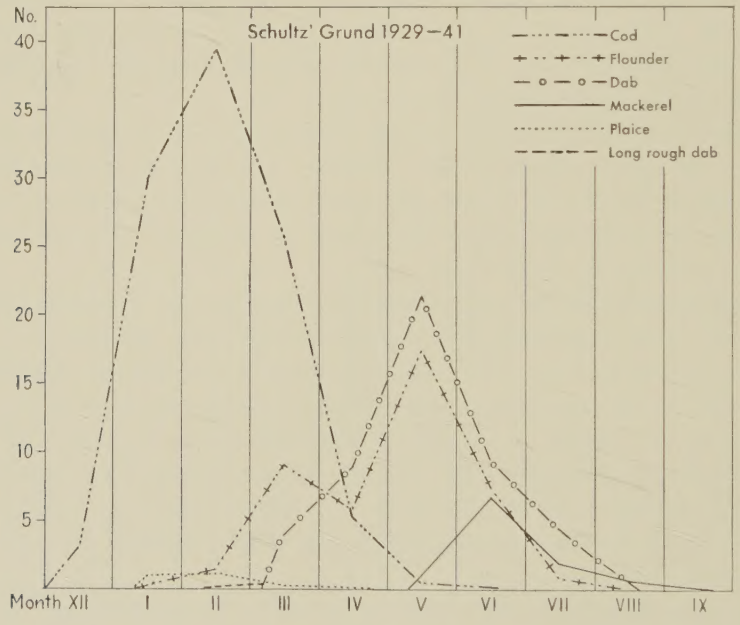
The plankton content of the samples thus forwarded was determined after the whole sample had been left in a measuring glass for 15—20 minutes; at this time the plankton had settled, and the volume of its organisms was then read to the nearest interval for each 5 cm^3 so as 25, 30, 35 cm^3. At the same time the principal components of the samples were taken down as algae, copepods, sagitta or other constituents. After this fish eggs and larvae were sorted off, determined and measured. The diameters of the eggs were read to 0.05 mm., and each diameter was taken down in tabular form. The eggs of the individual species in this way turn out to group in typically one-topped graphs, which also clearly show the mean size of the eggs of the species in question.

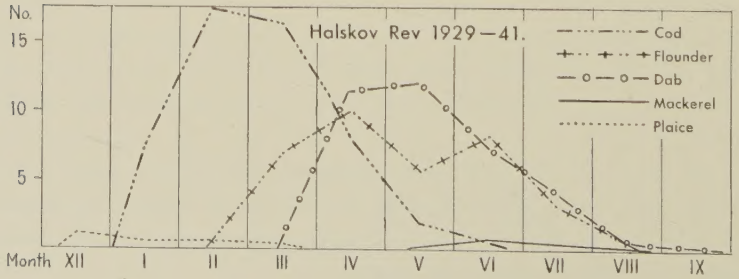
For the determination were also used the embryo if present and the presence or lack of oil globules in the egg.

In this work only the eggs of those fishes are considered that are valuable in a commercial respect: cod, plaice, flounder, dab, long rough dab, mackerel, sprat and anchovy; the eggs of fishes that are not utilized by the commercial fishery, for instance rockling and dragonet, are not included.

The Hensen net is a very slowly working gear and allows most fish larvae to escape; this means that the few larval fish taken by the net are by no means representative of the local occurrence of these fishes. For this reason the fish larvae found in the samples, though they were determined, are not included in this report.







Figs. 1—3. Fish eggs in average number per haul from Hensen net in the years 1929—41, which amounted to 11634 eggs from Anholt Knob lightship, 9257 eggs from Schultz' Grund lightship and 8160 eggs from Halskov Rev lightship.

Table 1. Average number of eggs pr. haul in the various months 1929—41. *A*: Anholt Knob, total Number of eggs: 8160. *B*: Schultz's Grund, total number of eggs: 9257. *C*: Halskov Rev, total number of eggs: 11634.

Month	No. of hauls	Cod	Plaice	Flounder	Dab	Long rough dab	Mackerel	Herring	Flounder and Dab
A.									
I	86	7.52	0.23	0.12	..	..	..	..	0.12
II	73	10.07	0.20	0.17	0.23	0.59	..	..	0.40
III	78	10.19	0.04	0.25	1.68	3.00	..	..	1.93
IV	84	3.35	0.03	4.96	4.95	0.49	..	..	9.91
V	55	0.31	..	4.40	19.90	..	0.98	..	24.30
VI	55	0.15	..	1.53	41.55	0.02	28.20	..	43.08
VII	57	0.06	..	0.02	13.74	..	21.37	..	13.76
VIII	54	..	..	..	0.15	..	1.81	..	0.15
IX	52	..	..	..	0.04	..	0.16	..	0.04
X	58	..	..	..	..	..	0.04	..	..
XI	54	..	..	..	..	..	..	..	..
XII	47	0.91	..	..	..	..	..	..	..
	753	..	..	..	..	..	..	..	..
B.									
I	42	30.00	0.78	0.24	..	..	..	0.10	0.24
II	35	39.65	0.83	1.71	..	0.04	..	0.10	1.71
III	39	25.90	0.25	9.13	4.23	0.25	..	0.03	13.36
IV	48	5.44	0.02	5.92	8.98	0.02	..	0.04	14.90
V	53	0.40	..	17.64	21.53	..	1.00	0.04	39.17
VI	50	0.04	..	7.50	9.54	..	6.96	..	17.04
VII	53	..	..	0.86	4.42	..	1.98	0.02	5.68
VIII	49	..	..	0.02	0.63	..	0.40	..	0.65
IX	49	..	..	..	..	..	0.26	0.02	..
X	46	..	..	..	..	..	0.04	1.00	..
XI	48	0.02	..	..	..	..	..	0.04	..
XII	43	3.25	..	..	..	..	..	0.04	..
	555	..	..	..	..	..	..	..	..
C.									
I	78	7.18	0.12	..	..	..	..	0.01	..
II	59	17.61	0.10	0.57	..	..	..	0.02	0.57
III	79	16.24	0.14	6.76	0.30	0.05	..	..	7.06
IV	81	8.30	0.07	9.96	11.44	0.03	..	0.02	21.40
V	50	2.06	..	5.64	12.16	0.02	0.02	0.04	17.80
VI	49	0.53	..	8.10	7.51	0.04	0.65	0.08	15.61
VII	48	..	..	3.27	4.01	..	0.39	..	7.39
VIII	49	..	..	0.57	0.29	..	0.02	..	0.86
IX	19	..	..	..	0.05	..	..	..	0.05
X	22	..	..	..	..	..	..	1.54	..
XI	22	..	..	..	..	..	..	0.49	..
XII	32	..	0.21	..	..	..	..	..	..
	588	..	..	..	..	..	..	..	..

Cod.

The literature on the spawning of the cod in the Danish waters is comparatively rich. Hitherto, however, the quantitative investigations mostly deal with the numbers of larvae and 0-Gr. fish because these categories, better than the numbers of eggs, are apt to tell us whether the year in question is a rich or a poor spawning year. This is rather obvious because the cod produces such an abundance of eggs, that far less than 1 $^0/_{00}$ of the eggs spawned may be reckoned to develop into mature individuals whereas about 10—12 $^0/_0$ of the older youngs of the 0-Gr. must be supposed to reach this stage (cp. POULSEN, 1944). Under the present conditions the cod, even in the poorest spawning years, is supposed to produce sufficient eggs

Table 2. Average number of eggs per haul (see p. 7) in the different spawning seasons 1929—42. Halskov Rev.

Years	No. of hauls	Cod	Plaice	Flounder	Dab	Long rough dab	Mackerel	Flounder and Dab
1929—30	64	28.56	0.10	32.25	28.21	..	1.00	60.46
30—31	64	49.16	0.66	16.65	49.90	0.25	1.20	66.55
31—32	64	23.21	0.60	32.45	28.75	0.50	4.33	61.20
32—33	58	40.93	0.52	16.42	44.65	0.30	0.40	61.07
33—34	63	45.84	0.13	42.75	21.80	..	0.33	64.55
34—35	64	81.83	0.30	52.83	31.70	..	2.05	84.53
35—36	64	49.33	0.30	68.69	40.85	..	0.50	109.54
36—37	54	111.55	0.67	75.53	49.27	0.10	3.25	124.80
37—38	56	42.01	0.78	35.55	30.08	..	0.50	65.63
38—39	32	47.67	0.58	14.92	64.25	..	..	79.17
39—40	27	39.50	..	43.17	53.00	0.25	0.33	96.17
40—41	37	17.33	2.33	19.50	26.00	0.25	0.50	45.50
41—42	..	18.25	1.50	..	..	..	..	..

Table 3. Average number of eggs per haul (see p. 7) in the different spawning seasons 1929—41. Schultz's Grund.

Years	No. of hauls	Cod	Plaice	Flounder	Dab	Long rough dab	Mackerel	Flounder and Dab
1929—30	52	98.30	2.60	67.88	56.39	1.50	16.35	124.27
30—31	49	77.15	1.50	29.00	47.80	..	23.75	76.80
31—32	51	66.70	1.35	50.45	43.05	0.20	13.35	93.50
32—33	50	85.72	1.35	24.43	23.92	1.00	7.25	48.35
33—34	50	176.55	4.25	39.10	33.50	..	6.35	72.60
34—35	48	107.75	0.50	39.27	16.42	0.25	3.83	55.69
35—36	46	105.25	1.28	53.25	58.10	..	3.25	111.35
36—37	58	123.50	3.50	118.75	23.00	1.00	12.70	141.75
37—38	40	113.75	1.25	65.25	84.17	..	10.00	149.42
38—39	37	103.75	1.25	38.33	137.74	..	11.66	176.07
39—40	27	12.93	..	9.36	98.82	..	5.90	108.18
40—41	22	0.33	..	..	5.58	..	1.58	5.58

Table 4. Average number of eggs per haul (see p. 7) in the different spawning seasons 1929—41. Anholt Knob.

Years	No. of hauls	Cod	Plaice	Flounder	Dab	Long rough dab	Mackerel	Flounder and Dab
1929—30	65	33.65	0.42	10.88	102.01	1.50	60.00	112.89
30—31	67	15.07	0.75	6.20	110.07	3.45	42.50	116.27
31—32	67	43.42	0.43	34.56	113.10	5.63	51.50	147.66
32—33	52	25.83	0.42	35.92	53.00	4.25	29.00	88.92
33—34	71	40.45	0.45	5.76	25.96	7.00	33.41	91.72
34—35	67	35.10	0.88	7.51	79.68	4.25	20.75	87.19
35—36	67	29.55	0.63	15.51	61.00	2.75	12.85	76.51
36—37	63	37.70	0.48	8.08	129.68	6.25	167.33	137.76
37—38	59	24.18	0.48	9.65	122.43	2.92	25.50	132.08
38—39	60	25.40	..	4.98	49.25	2.00	30.33	54.23
39—40	45	11.08	..	17.25	75.65	1.00	43.70	102.90
40—41	44	11.05	..	..	..	1.75	76.01	165.90

for the development of one of the very rich year-classes of cod if conditions are otherwise favourable. However, it is naturally of great interest to examine the quantitative variation of the production of eggs throughout a series of years, and we will begin with this material because the cod is the second most important utility fish of our waters, being second in value only to the plaice, and because the present material is particularly well suited for the study of the egg production of this fish.

The direct quantity of eggs could not be used as a representative of the amount of spawning, *i. a.* because the cod spawns in the coldest winter months, at which season the light-vessels were often withdrawn, or other circumstances have caused that the samples could not always be taken with the desirable regularity. As a standard of value I have therefore chosen to use the average number of eggs per haul for each month within the spawning period. The average figure for the year in question is taken as the average of the mean figures of the months within the spawning period. These figures appear from Tables 2, 3 and 4.

For the other kinds of fish eggs the graphs have been carried up to 1941, but this was not possible for the cod, the maximum spawning of which takes place during the first months of the year; but during these very months the light-vessels were often withdrawn on account of ice in the last years of the period examined. When the light-vessels were re-placed about March, the numbers of cod eggs were so low, that the ordinary spawning must be said to have come to an end, and so the eggs found in March and later on could tell nothing about the course of the spawning during the first months of the year.

Time and Place of Spawning.

It appears from the columns of Fig. 4 and the figures of Table 1 that the richest spawning takes place at Schultz Grund, the poorest at Anholt where the number of eggs fished is only half as large as at Schultz Grund. The graph for cod eggs at Halskov Rev runs nearly midway between the other two. The cod eggs of Halskov Rev and, accordingly, probably also the stock of spawning cod in this locality thus seems to be considerably fewer in number than at Schultz Grund. In a previous paper by Dr. E. M. Poulsen (1944) on these stocks of cod the quantities

of eggs were stated to be nearly equally large at Halskov Rev and at Schultz Grund; this mistake is due to an erroneous labelling of the material, which was not observed until some time later.

It further appears from the columns that the spawning at Schultz Grund and Anholt Knob begins in December (at Schultz Grund a single cod egg was even found at the end of November) while at Halskov Rev it never starts until January. This is undoubtedly due to the fact that the Kattegat at this time of the year has a higher temperature than the Belt Sea. We see, however, that for all three areas January—February—March are the proper spawning months with a maximum occurring from the end of February to the beginning of March: at Anholt Knob the maximum spawning is equally distributed over January—February—March; in all essentials this is also true of Schultz Grund though there seems to be an inconsiderable rise of the spawning in February. Halskov Rev, however, still seems to be a little behind: its maximum spawning does not occur until February—March. This agrees well with POULSEN's investigations (1931) on cod spawnings in all Danish waters.

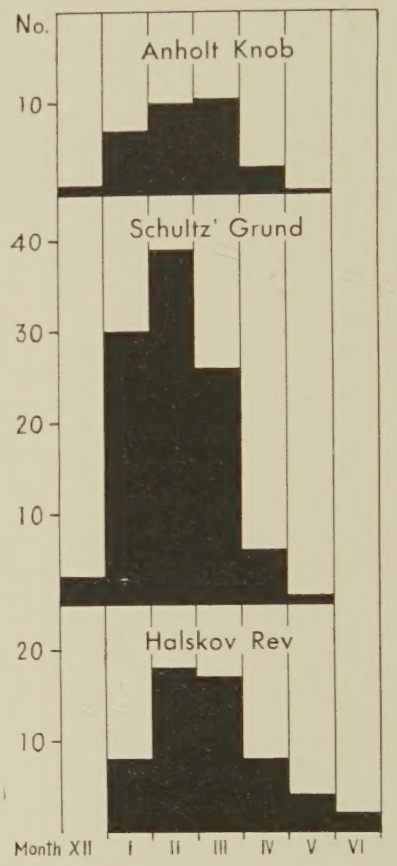


Fig. 4. Eggs of Cod. 1929—1941. Average number per haul in spawning month.

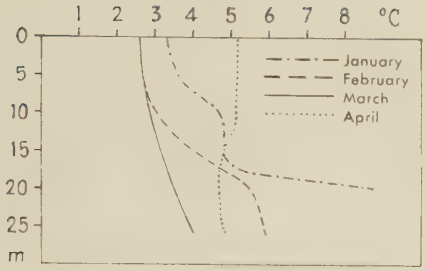
The annual Variation of the Quantity of Eggs.

In calculating the quantitative variation of the eggs at the three light-vessels for the years 1930—39 we find the correlation between Halskov Rev and Schultz Grund to be + 0.32 and between Schultz Grund and Anholt Knob + 0.34. This is a very low correlation, and it shows us that the quantity to a very small extent only varies in the same way from year to year at the three light-vessels. It should be remembered, however, that the quantity of eggs captured is extremely small as compared to the total egg quantity of the locality. During the 10 years of investigation only 2,500—4,000 cod eggs were taken at each light-vessel, which makes a total of about 10,000 eggs. Each of these eggs was measured and examined. This may seem to be a comparatively large quantity, but it is highly inferior to the number spawned by one cod in one season.

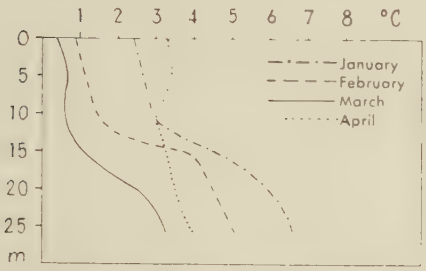
It appears from the figures of Table 4 that the spawning differs somewhat in various years: 1932, 33, 36, 38 and 39 seem to have been poor spawning years whereas 1937 was a rich spawning year of the cod at all three light-vessels. At Schultz Grund the 1934 spawning seems to have been heavier than that of other years; at Halskov Rev there was a rich spawning in the following year 1935, and the maximum spawning occurred in 1937.

Variation in the Time of the Occurrence of the Eggs.

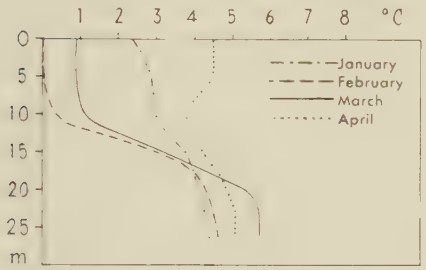
The maximum of the spawning is not quite regular in time but may vary somewhat from one year to another. An attempt has been made to find out whether this fact is connected with the temperature or the salinity of the water, either at the bottom or at the surface. POULSEN (1931)



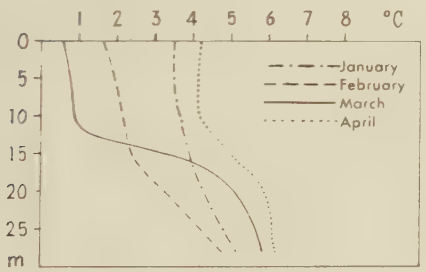
1. Schultz' Grund 1935. January



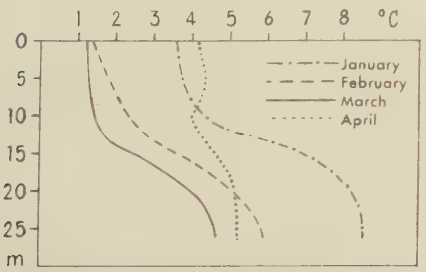
2 Schultz' Grund 1931. February



3. Schultz' Grund 1937. Febr.-March)



4. Anholt Knob 1932. (March)



5. Schultz' Grund 1936. (Jan.-Febr.-March)

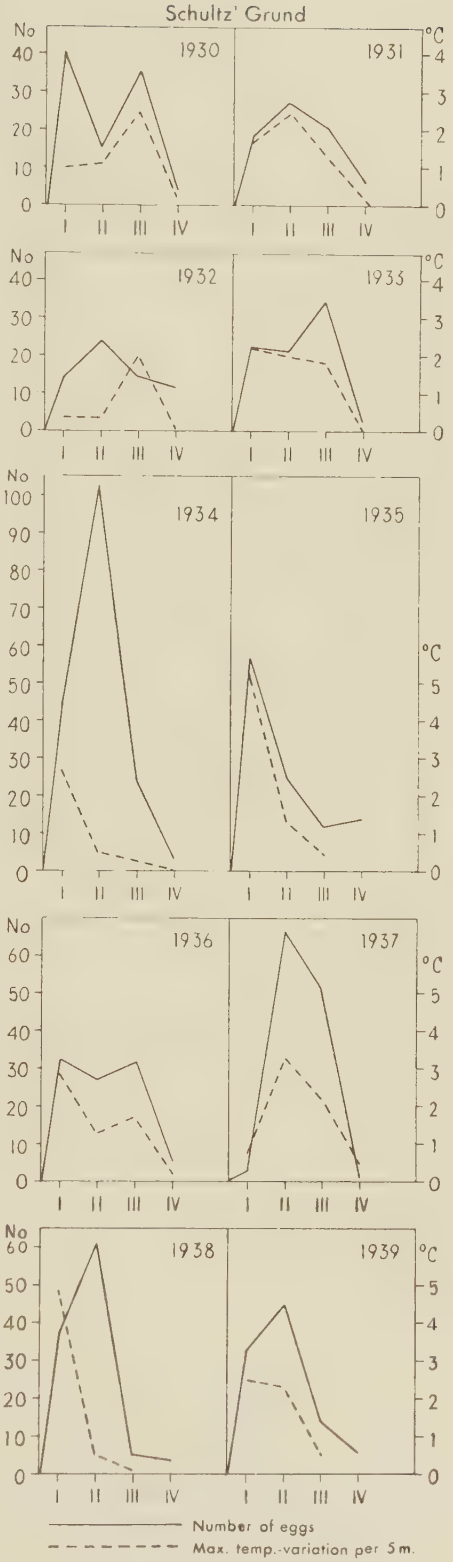


Fig. 5. Nos. 1—5 showing water temperature from surface to bottom in the first four months of the year, which shows the relation between the discontinuity of the temperature from the surface to the bottom and the spawning of the cod. A big discontinuity seems to favour the spawning. — In No. 1 the cod spawned mainly in January, no. 2 in February, no. 3 in Febr.—March, no. 4 in March and no. 5 in Jan.—March. The same relation between spawning and discontinuity in the waterlayers is shown for Schultz Grund 1930—1939 in the right side of the figure.

says that the cod spawns at temperatures between 3 and 7° C., but this is a very common temperature at this time of the year, and so it seems impossible that this can be the cause of the lesser annual variations. The extent of the incongruities between the annual variations of the egg quantity and the temperature and salinity, respectively, seems to speak against a direct dependence. On the other hand there seems to be some dependence on the difference in temperature between the upper and the lower water layers: where distinct discontinuity layers occur they seem to favour the spawning.

O. Sund (1936) was the first to call attention to this circumstance: by means of echo soundings he found out that the Lofoten cod during the spawning months mostly stayed in the very discontinuity layer or its immediate vicinity. So it was quite natural to examine whether a dependence could be found between the quantity of cod eggs and the variational width of the temperature, *i. e.* how much the temperature varies within a certain part, in this case calculating 5 m., of a given water column.

In the first 5 diagrams marked 1—5 in Fig. 5 the water temperatures from bottom to surface are given for the first four months of the year. The five chosen graphs (Fig. 5, 1—5) show distinctly that the spawning coincides with great variations of temperature in the water layers. If these variations occur early in the year, as in 1, the cod also spawns early. If they take place at a later point of time, the spawning of the cod is equally late (3). The spawning of the cod extends over a longer period if the variation of temperature in the water holds for a long time as will appear from 4 and 5.

We have here seen 5 chosen instances of the spawning of the cod following the variation of temperature in the water. These five instances are of course among the most typical of the present material. Naturally the existence of great variations of temperature in the water does not alone determine the place and time of the spawning of the cod, but both the fact established by Sund that the Lofoten cod during the spawning period mainly lives in the discontinuity layer and the results of the present examinations of eggs in Danish waters are strongly indicative of a certain dependence of the spawning of the cod on the existence of great variations of temperature in the water column. As will be seen from an examination of the graphs of Fig. 5 this is not the only factor involved though it seems to be of some influence. Further investigations in the future to the effect of establishing whether the eggs found during these maxima of the discontinuity layer are recently spawned eggs will of course be of interest because they may tell us whether the cod mainly spawns in the very discontinuity layer as must be concluded from Sund's investigations, or whether the special conditions of current in the discontinuity layer indice an accumulation of the eggs. As demonstrated by Poulsen (1944) also an early and cold winter, in which even the bottom water cools down already in December—January, seems to delay the maturation and, accordingly, the spawning of the eggs.

Flat-fish.

Distinction between the Eggs.

In the Danish waters the most common flat-fishes are plaice, common dab and flounder. The plaice is the earliest spawner of these three fishes: at the light-vessels from which the samplings were made it spawns during the first four months of the year. A few plaice eggs were found already in December, but they were never found later than April. For the Belt

Sea water A. C. Johansen (1912) gives the period from November to the beginning of May, for the Kattegat the period from November to April, which to all essentials is the same period as, in 1929—43 though a little longer. Plaice eggs can easily be distinguished from the eggs of other fishes by their great size; they range between a little more than 1.5 and fully 2 mm. With the other species the question is more difficult. Firstly, the spawning periods of the flounder and the common dab overlap, the former lasting from January to July, the latter from March to well into August. Secondly, there is a rather small difference in size between the eggs of the two species: the eggs of the flounder vary between 0.80 and 1.15 mm., those of the common dab between 0.60 and 1.0 mm. in diameter. In other words also the size of the eggs of the two species overlap to some extent, and so there is some uncertainty in the determination — based on measurings alone — of the small number of eggs that is composed of the biggest dab eggs and the smallest flounder eggs.

Fig. 6. Percentage distribution of flounder (F) and dab (D). First figures apply to the fishes of a age of three years and more. Figures in brackets apply to the full catch in the area in question.

Heinen (1912) divided the eggs into obvious flounder eggs and obvious dab eggs; the rest of them he then divided in proportion to the numbers of the two groups of safely determined eggs. This procedure is very inaccurate, particularly because the mean size of the eggs decreases rather considerably with the advance of the season. In this way nearly all flounder eggs at the end of the spawning season fall within the established limits of dab eggs. Kramp (1913) plotted a graph on the basis of the egg diameters, thus getting a distinctly two-topped graph though with a slight overlapping in the middle; then the number of eggs was divided discretionally by a divisional line through the minimum of the graph.

For the present investigation I have used Kramp's method, measuring and tabularizing each egg, but besides this I have noticed that the yolk of the dab egg has a more bluish hyaline colour than that of the flounder egg, which seem to have a more yellowish, turbid colour. The eggs dealt with here are not fresh but taken from material fixed in formalin. In doubtful cases, when the graphs were congruent and the egg contained no embryo for a closer study, I used this colour of the eggs as an aid to the determination of the species to which the egg belonged.

In this way all eggs were divided into dab eggs and flounder eggs. Of course this clas-

sification is not absolutely safe, but when the material is to be used statistically, the inevitable errors seem to be rather small, so that this method of distinguishing the eggs must be considered absolutely adapted to its purpose. According to this all eggs of the three species of fish arranged themselves in the following percentages.

	Anholt Knob	Schultz Grund	Hälskov Rev
Plaice	0.2 %	0.67 %	0.5 %
Flounder	2.2 %	7.52 %	9.5 %
Dab	97.6 %	91.81 %	90 %

With a view to controlling the value of this division a counting was made of the flounder and common dab that were captured by the Danish Biological Station in 30 minutes' hauls with the eel seine in the years 1936–39. The percentage distributions of the figures were calculated for each area of capture and plotted in the map Fig. 6 (figures in brackets). The figures outside the brackets give the percentage proportion between the stocks of 3 year old and older year-classes of flounder and common dab because these species do not become mature until they are as old as that. The proportional thus shows the ratio between the mature fishes within the area. Here the figure for the common dab is perhaps a little too high because the dab reaches the stage of maturity later than the flounder, in many cases not until its fourth year of life. If, at the same time, regard is paid to the fact that the eggs spawned per season by a common dab are much fewer than those spawned by a flounder (there are statements to the effect that one mature dab on an average spawns 100,000 eggs per season against up to the maximum of 1 million eggs spawned by one flounder), there is even a further difference of the figures, that of the flounder being constantly too low, that of the dab too high. We then see that there is a comparatively close accord between the stocks of common dab and flounder with the eggs they may be estimated to have spawned and the found eggs when they are distributed according to the method applied here. At the same time we notice that the numbers of flounder eggs and the stock of adult flounder increase from the Kattegat towards the Belt Sea waters.

Plaice.

In spite of the fact that the plaice is the most important utility fish of the Danish waters the stock of plaice is comparatively small in comparison with the other flat-fishes. The stock of plaice of our inner waters makes up less than 1 per cent. of the total stock of flat-fishes. Among other things this is due to the fact that the plaice as the most valuable among the flat-fishes is the object of a much intenser fishery than the other fishes, the latter are less exposed to overfishing and are thus able to spread on the cost of the plaice, which is more valuable to the commercial fishery. It is well-known that efforts have been made for some years to counter-act this state of things, and with good effect, by transplanting small plaice from over-crowded coastal waters to other areas with better conditions of nutrition. As emphasized by ERIK M. POULSEN (1953) it would also be advantageous in an economic respect to decrease the stock of less valuable fishes, for instance dab, thus giving room for a still higher number of plaice.

Time and Place of Spawning.

From the three light-vessels a total of only 153 plaice eggs were fished during the period 1929–41. It is impossible to draw any very reliable conclusions from this small material.

but generally speaking it may be stated that the plaice spawns during the first three months of the year, the spawning maximum occurring in January and February. As late as April a few plaice eggs are sometimes met with, but only at the beginning of the month, so that they must be supposed to have been spawned near the end of the previous month. From one light-vessel (Halskov Rev) the 1941 material contains 6 plaice eggs in December. These 6 eggs make up a maximum in December for this light-vessel because the total number is so small. This is a distinct proof that the number of plaice eggs is much too low to permit of any fargoing conclusions, but it appears from Tables 1—4 that the number of plaice eggs at Schultz Grund is nearly twice as large as at Anholt Knob and Halskov Rev.

Flounder.

Time and Place of Spawning.

The spawning begins already in January—February (Fig. 7); even in March it is not very heavy, and it does not become extensive until April. The winter temperature is lower in the Baltic and the Belt Sea than in the southern Kattegat. This also influences the spawning, which at Halskov Rev on an average begins a fortnight later than at Schultz Grund. At Anholt Knob the spawning reaches its maximum in April—May; at Schultz Grund it shows a two-topped graph with the first maximum in March, the second and bigger one occurring at the beginning of May. The graph for Halskov Rev is distinctly two-topped, but the maximum occur later, in April and June. The two-topped graph is particularly distinct at Schultz Grund in 1930 and 1934.

In some years the first spawning is by far the bigger, for instance at Halskov Rev in 1937, but in most cases the later spawning predominates, for instance at Schultz Grund in 1937, 1938 and 1939 and at Halskov Rev in 1934 and 1936. It is somewhat difficult to decide how this two-phased quantity of eggs appears. One theory is that it is caused by an inflow of eggs from without with the current, which in the upper water layers goes northwards through the Belts from the Baltic (cp. J. P. Jacobsen, 1937). The second top of the graphs (Fig. 7) showing the quantities of eggs would then be due to eggs from the Baltic, carried along with the current, because the flounder here spawns somewhat later than in the Belt Sea and the southern Kattegat. An objection to this supposition is that the second top of the graph illustrating the quantity of eggs (Fig. 7) occurs already in May at Schultz Grund but not until June at Halskov Rev. If the eggs had come from the south,

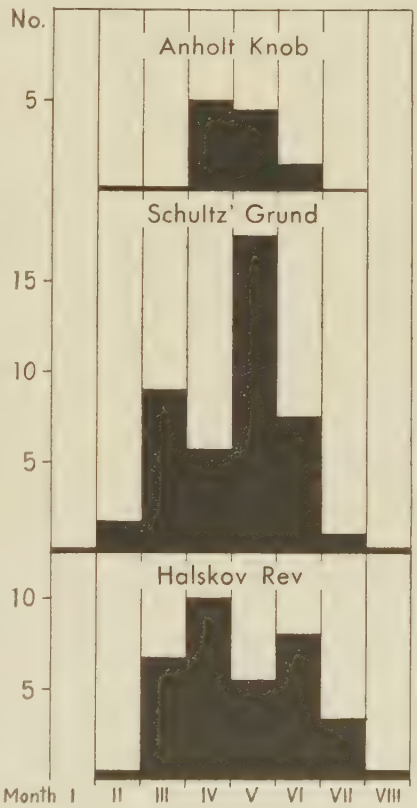


Fig. 7. Eggs of Flounder. 1929—1941. Average number per haul in spawning month.

Fig. 8. Relation between spawned eggs of flounder and the bottom temperature. ———— Number of eggs per haul. – – – Temperature of the water at the bottom.

they must reach Halskov Rev first. The late quantities of eggs in the second top of the graphs cannot thus essentially have appeared in this way.

On the other hand it is well-known that the flounder is distinctly a low water fish, which also in winter is found in the shallow water of the shoals. As the water of these localities in winter is considerably colder than the bottom water in the channels, it may seem, judging from the egg graphs, that the flounders make up two stocks, one standing at the bottom of the channels and one living in the shallower water. If this hypothesis is correct, it is quite natural that the stock of the channels should spawn first while the spawning of the stock of the low water is delayed by a month. The pronounced division between the spawnings of the two stocks must then be explained by the fact that at the very depth of about 15 m there is a very strongly marked difference between the warmer bottom water and the colder surface water during the winter months. The circumstance that the graph illustrating the egg quantity at Anholt Knob is not two-topped is accounted for by the nearly total lack of shoals in this area, so that all flounder of this locality belong to the stock living in deeper water.

Annual Variations of the Quantity of Eggs.

A look at the amounts of the individual years (Tables 2—4) will show that 1931 was a poor spawning year at all three lightvessels; 1933 was poor at Schultz Grund and Halskov Rev, but rich at Anholt Knob. And 1937 showed a very extensive spawning at Schultz Grund and Halskov Rev, but was a poor spawning year at Anholt Knob. If we look at all years within the period, we find no connexion between spawning and temperature; but if we select the years showing larger fluctuations, we find some degree of dependence (cp. Fig. 8). 1931 was a cold year with cold bottom water in March—April at all three lightvessels and it also gave a poor spawning. At the same time of the year 1932 comparatively

warm bottom water was standing at Anholt Knob, accompanied by a rich spawning of the flounder stock of this light-vessel; at the same time the water at the other two light-vessels showed temperatures of mean height, which corresponds fairly well to the egg quantities captured. In 1937 there was cold bottom water in March—April at Anholt Knob, but warmer water along the bottom at Schultz Grund and Halskov Rev. At the last-mentioned light-vessels this year gave the largest amount of flounder eggs within the period 1929—41, and in the same year the quantity at Anholt Knob was comparatively small. Apparently lesser fluctuations of the temperature do not seem to have an influence on the amount of eggs, but very cold water of less than 2° C. seems to delay the spawning very much.

The amount of eggs has also been compared with the salinity, but there seems to be no connexion between these two factors as will appear from the following comparison from the first 5 years.

Schultz Grund.

1930		1931		1932		1933		1934	
‰	Eggs	‰	Eggs	‰	Eggs	‰	Eggs	‰	Eggs
3.33.0	29.5	28.9	0	28.6	11.50	31.5	4.33	28.4	8.60
4.32.9	37.5	31.6	2.40	33.1	15.40	31.6	2.75	30.8	5.00
5.34.1	11.33	33.2	11.25	33.6	17.00	32.7	8.75	33.5	16.25
6.33.4	21.0	33.7	10.75	33.1	5.80	33.4	7.20	31.4	6.50

Halskov Rev.

1930		1931		1932		1933		1934	
‰	Eggs	‰	Eggs	‰	Eggs	‰	Eggs	‰	Eggs
3.28.3	8.50	22.1	2.25	19.5	2.83	24.8	3.70	19.8	4.25
4.29.4	6.25	24.1	5.50	29.4	15.12	24.5	2.67	25.2	5.25
5.32.0	4.00	29.9	4.25	31.4	2.50	28.1	4.25	31.2	3.00
6.32.3	13.00	31.0	3.40	31.5	10.00	31.4	4.60	27.3	28.00

Anholt Knob.

1930		1931		1932		1933		1934	
‰	Eggs	‰	Eggs	‰	Eggs	‰	Eggs	‰	Eggs
3.33.6	0.75	33.3	0.90	33.1	10.66	33.6	5.50	32.8	0.88
4.34.2	3.25	33.8	4.17	34.5	14.77	33.5	9.00	33.6	1.80
5.34.4	2.00	34.1		33.9	5.00	33.4	14.25	34.0	1.00
6.34.4		33.4		33.9	1.75	33.7	6.75	33.9	

Common Dab.

Time and Place of Spawning.

The common dab is extremely numerous in the Danish waters. Judging from summer catches with the eel-seine since 1927 there are more older dab in the Belt Sea water than in the Kattegat, but the plankton hauls show a considerably larger amount of dab eggs in the Kattegat than in the Belt Sea. The figures for the period 1929—41 are: Anholt Knob 4,737 specimens, Schultz Grund 2,479 specimens and Halskov Rev 2,114 specimens. It also appears

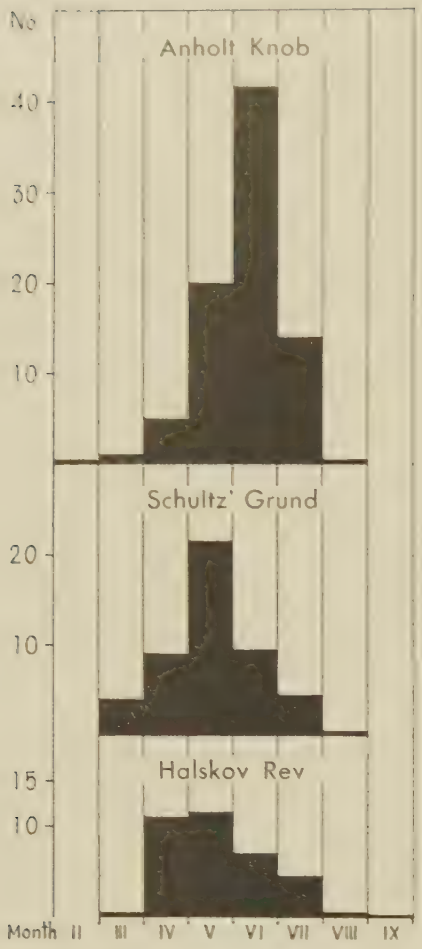


Fig. 9. Eggs of Dab 1929—1941. Average number per haul in spawning month.

from Fig. 9 that the earliest spawning begins at Anholt Knob where we have the warmest water in winter, but that the maximum of the spawning is reached more rapidly in the southern waters. This seems to be connected with the fact that the heat of the summer asserts itself more rapidly in the southern waters than in the northern and central Kattegat. The common dab seems to begin an intense spawning during this very rise of the temperature of the water.

If we look at the 12 years as a whole, in which the eggs were collected, we notice that the maximum spawning of the common dab falls in April—May—June both at Halskov Rev and Schultz Grund, a little later in the latter locality where the month of May is the principal spawning time. At Anholt Knob, however, the spawning takes place in May—June—July with a pronounced maximum in June.

The latest spawning occurs in years with a low temperature in April. It will be natural in this connexion principally to look at Anholt Knob where we found the large amounts of eggs.

In the years of early spawnings with maxima in May as in 1932, 1934, 1936 and to some extent 1938 the bottom temperature is very high already in April, 5—6° C. The average temperature for April in these 4 years is 5.6° C.; in the other 8 years of the period examined the month of April shows a average bottom temperature of 4.4° C. During these years with cool water in spring the maximum spawning of the common dab occurs in June as will be seen from the following survey.

Late spawning

(June)

Year	April temperature
1929	4.6
30	4.8
31	4.4
33	4.3
35	5.2
37	4.1
39	5.0
40	2.4
Average...	4.4

Early spawning

(May)

Year	April temperature
1932	6.2
34	4.9
36	5.6
38	5.7
Average...	5.6

Long Rough Dab.

Although this fish is comparatively common both in the Kattegat and the deeper channels of the Belt Sea only few of its eggs were taken in the Hensen net, during the whole period 1930—41 a total of 7 eggs at Halskov Rev, 13 at Schultz Grund and 318 at Anholt Knob. No doubt these figures are too low, for at the same time remains of egg membranes were comparatively often found in the plankton taken out of the Hensen net, which may seem to indicate that the eggs of the long rough dab, which are very big and fragile, are exposed to being crushed in the Hensen net.

Time and Place of Spawning.

From the numbers of eggs it is seen that the stock of spawning rough dab rises considerably in number as we move northwards in the Kattegat. Between Schultz Grund and Anholt Knob the amount of eggs rose from 13 to 318 in all samples together. No doubt the 318 eggs from Anholt Knob must also be considered much too small a number, but in connexion with the results of the other light-vessels it gives an idea of the amount of spawning rough dab in the different areas. At Anholt Knob the rough dab spawns from February to April with a pronounced maximum in March (Fig. 10).

The annual Variation of the Quantity of Eggs.

During an examination of the numbers of larvae in the Belt Sea throughout the period 1923—35 Poulsen (1936) found that particularly 1923, 1930 and 1932 were good brood years.

The numbers of eggs at Anholt Knob during the period 1930—41 show that 1931 was a rather poor, 1932 an average spawning year and that the largest amounts of eggs occurred in 1934 and 1937. In other words a year with many eggs may well develop into an average brood year and *vice versa* as will be seen from the years 1930 and 1932.

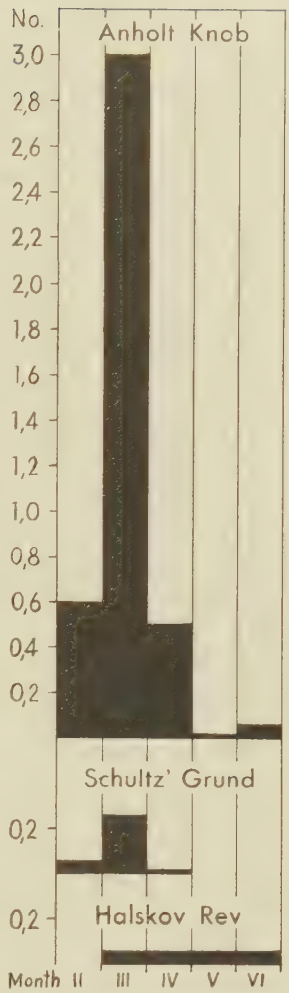


Fig. 10. Eggs of Long rough dab 1929—1941. Average number per haul in spawning month.

Mackerel.

Time and Place of Spawning.

The material is rather poor as far as the mackerel is concerned, but it appears distinctly from Fig. 11 that the spawning takes place in June—July, the same time as that found by Johansen (1925). Nilson (1914) reports that in water with a salinity below 26 ‰ he found few mackerel eggs. In June—July a higher salinity is found only below 15 m. depth at Anholt Knob and in July only below 20 m. at Schultz Grund. At Halskov Rev a salinity of this height is reached only immediately above the bottom. Correspondingly, the quantity of eggs decreases rapidly from Anholt Knob to Halskov Rev.

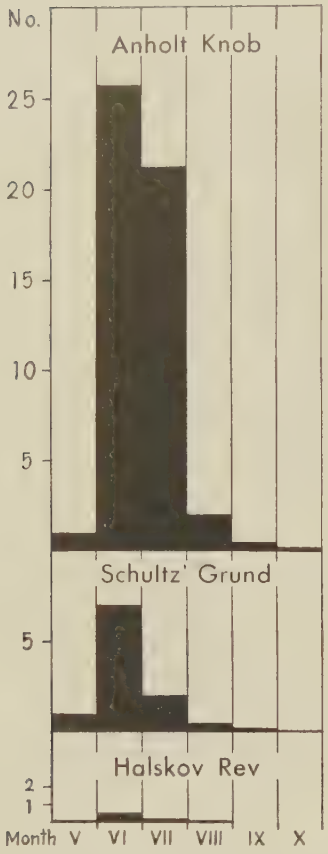


Fig. 11. Eggs of Mackerel 1929—1941. Average number per haul in spawning month.

The annual Variation of the Quantity of Eggs.

Previous investigators (A. C. Johansen, 1929 and Aage J. C. Jensen, 1933 and 1939) have established a dependence of the presence of the fish on various external factors. In my material of eggs it seems impossible to find a relation between the spawning and various outer factors: no correlation could be found between the amount of eggs and the temperature of the water, neither a short time before, nor during the spawning. It was equally impossible to find a relation between high salinity at the bottom (and hence the number of immigrating fish) in May—June and the quantity of eggs in the same year.

Furthermore, the annual variation of the quantity of eggs has been compared with the catches of mackerel in Danish waters, but also in this case no very distinct accordance could be established between the stock of fish and the eggs spawned. The years 1935, 1936, 1938 and 1939, for instance, show average to rich occurrences of fish but were extremely poor in eggs. 1937 shows an enormous quantity of eggs at Anholt Knob, but the stock of fish was only of mean size in this year.

Sprat.

The proper breeding area of the sprat, which is very common in the Danish waters, is not situated near to the localities examined. A spawning area extends from the Skagerak partly some way into the Oslo Fjord, partly southwards into the Kattegat to a short way N. of Anholt (cp. Höglund, 1938).

The eggs are found from the middle of April till the middle of August, the highest frequencies occurring in April—May. The highest number of eggs, a total of 19, was found at the Anholt Knob light-vessel; only 1 egg was found at Halskov Rev, and no eggs were observed at Schultz Grund.

Larval sprat were taken in a somewhat higher number; this is undoubtedly a proof that the localities are situated outside the spawning area of the sprat, while greater numbers of larvae, on account of their higher age, could be carried away from the spawning area by the current. The larvae mostly occur in June and July. Also the fact that the Anholt Knob light-vessel took most larvae in June while the light-vessels at Schultz Grund and Halskov Rev took them in July, indicates that the larvae and eggs are carried in from the north by the current.

Anchovy.

As eggs of anchovy were not formerly observed in the inner Danish waters, it should be mentioned that a few eggs of this fish were found in the June and July samples from 1938, 1940 and 1941. One egg was taken as early as May 5th, 1941. The eggs only occur in the samples from the two northernmost light-vessels, Anholt Knob and Schultz Grund, most of them at Anholt Knob: a total of 18 anchovy eggs were found in the samples from the Anholt Knob light-vessel; the Schultz Grund material contained only 6 anchovy eggs.

Conclusion.

In spite of the fact that the present investigations are based on a material of about 30,000 fish eggs, which have been collected regularly once a week during a period of 13 years, the detailed calculations show that the material in several respects is not comprehensive enough. It is a good illustration of the times at which our most important food-fishes spawn in the Danish waters (cp. the graphs Fig. 1—3). It is seen that the cod begins to spawn at the end of December. The proper spawning begins in January and continues throughout the first three months of the year. The most extensive spawning took place in the Kattegat in January—February March, in the Great Belt in February March. By the beginning of April the proper spawning is over, and only a few individuals are found to spawn in May or June. Finally the investigation makes it likely that the cod seeks out the local discontinuity layers and remains there during its spawning in the same way as demonstrated by Sund for the Lofoten cod; the present investigation further seems to indicate that pronounced discontinuity layers occurring early in the year tend to accelerate the spawning of the cod.

In the main the spawning of the plaice coincides with that of the cod although it ends earlier: after April no plaice eggs have been met with.

The next fish to start spawning is the flounder. It begins to spawn in February, but its proper months of spawning are March, April and May. As far as the flounder is concerned we have demonstrated the possibility that the southern Kattegat and the Belt Sea waters contain two stocks, one, spawning first, in the deeper channels and another, spawning somewhat later, in the lower water of the shallows and along the coast.

The next eggs met with are those of the dab. At Halskov Rev this fish spawns when the water begins to grow a little warmer, in April—May; at Schultz Grund the spawning maximum is not reached until May and at Anholt Knob not until June.

Though the long rough dab is very common in the northern Kattegat, only small numbers of its eggs were found here. A possible explanation of this fact is that these big and fragile eggs are crushed in the Hensen net, so that the eggs found are not illustrative of the actual amount of eggs. The spawning of this fish at Anholt Knob principally takes place in the month of March.

The latest spawner among the fish examined is the mackerel. This pelagic fish, which enters the Danish waters in order to spawn, mostly deposits its eggs in the Skagerak and the northern Kattegat, and no mackerel eggs were taken at Halskov Rev in the Great Belt during the period of investigation. They were found sparsely at Schultz Grund and very numerously at Anholt Knob. Here the mackerel spawns in the months of June—July.

LITERATURE

Blegvad, H. 1926: Om gode og daarlige Yngleaar hos Torsk og Rødspætter. — Dansk Fiskerit. 1926, No, 25.

— 1932: On the Flounder (*Pleuronectes flesus*) and the Danish Flounder Fishery in the Baltic. — Rap. et Proc.-Verb. des Réunions. 78.

Ehrenbaum, E. 1905—09: Eier und Larven von Fischen des Nordischen Planktons.

Ehrenbaum u. Strodtmann 1904: Eier und Jugendformen der Ostseefische. 1. Bericht. — Wiss. Meeresunt. N. I Abt. Helgoland. Bd. 6. H. 1.

Heinen 1912: Die planktonischen Fischeier und Larven der Ostsee. — Wiss. Meeresuntersuch. N. F. Abt. Kiel. Bd. 14.

Höglund, H. 1938: Ueber die horizontale und vertikale Verteilung der Eier und Larven des Sprottes (*Clupea sprattus* L.) im Skagerak—Kattegatgebiet. — Svensk Hydrograf.-Biol. Kom. Skrifter. Ny Ser. Biologi. Bd. II.

Jacobsen, J. P. 1909: Mittelwerte von Temperatur und Salzgehalt. — Medd. f. Komm. f. Havunders. Ser. Hydro. I. No. 10.

— 1925: Die Wasserumsetzung durch den Öresund, den Grossen und den Kleinen Belt. — Medd. f. Komm. f. Havunders. Ser. Hydro. Bd. II, 9.

Jacobsen, J. P., Johansen, A. C. 1908: Remarks on the Changes in Specific Gravity of Pelagic Fish Eggs and the Transportation of same in Danish Waters. — Medd. f. Komm. f. Havunders. Ser. Fiskeri. III, 2.

Jensen, Aage J. C. 1939: The Danish Forecasts of the Yield of some Fisheries. — Rap. et Proc.-Verbaux. 109.

— 1939: Udsigterne for Makrelfiskeriet i det østlige Skagerak og nordlige Kattegat i Forsommeren 1939. — Dansk Fiskeritidende 1939, p. 202.

— 1942: Udsigterne for Drivgarnsfiskeriet efter Makrel i det østlige Skagerak og det nordlige Kattegat i 1942. — Dansk Fiskeritidende 1942, p. 168.

Johansen, A. C. 1911: Zweiter Bericht über Eier, Larven und älteren Stadien der Pleuronectiden in der Ostsee. — Rap. et Proc.-Verbaux. 13. No. 6.

— 1912: Om Rødspætten og Rødspættefiskeriet i Beltfarvandet. — Skrift. Komm. Havundersøg. No. 7.

— 1925: On the Influence of the Currents upon the Frequenci of the Mackerel in the Kattegat and adjacent Parts of the Skagerak. — Medd. f. Komm. f. Havundersøg. Ser. Fiskeri. Bd. 7, No. 8.

Kramp, P. L. 1913: Report on the Fish Eggs and Larvae collected by the Danish Research Steamer "Thor" in the Langelandsbelt in 1909. — Medd. f. Komm. f. Havundersog. Ser. Fiskeri IV, 5.

— 1924: Fish Eggs and Larvae collected in the Belt Sea in March 1922. — Medd. f. Komm. f. Havundersøg. Ser. Fiskeri VII, 6.

Nilsson, David 1914: A Contribution to the Biology of the Mackerel. — Publ. de Circonstance. No. 69. Copenhague.

Otterstrøm, A. 1906: Eggs and Young Fishes in the Danish Waters. — Rep. Danish Biol. Stat. 13.

Petersen, C. G. Joh. 1902: The Biology of the Cod in the Danish Seas. — Rep. Danish Biol. Stat. 11.

Poulsen, E. M. 1931: Biological Investigations upon the Cod in Danish Waters. — Medd. f. Komm. Danmarks Fiskeri- og Havunders. Ser. Fiskeri IX, No. 1.

— 1933: Biology of the Dab in Danish Waters. — Rep. Danish Biol. Stat. 38.

— 1938: The Dab in the Danish Waters, Investigations on Stock and Growth. — Rep. Danish Biol. Stat. 42.

— 1945: On Fluctuations in the Size of the Stock of Cod in the Waters within the Skaw during recent years. — Rep. Danish Biol. Stat. 46.

Sund, O. 1936: Fiskeforsøk i Lofoten. 1936. — Årsberetn. vedk. Norges Fiskerier, No. 2. Lofotfisker. 1936.

DANSK RESUMÉ

Til Undersøgelse af Spørgsmaalet om Gydningstiden og de ydre Faktorers Virkning herpaa hos vore Nyttefisk er der, paa Foranledning af »Kommissionen for Danmarks Fiskeri- og Havundersøgelser« gennem en Aarrække taget regelmæssige Planktontræk med Hensen-Net fra følgende Fyrskibe: Anholt Knob, Schultz Grund og Halskov Rev. Planktontrækkene blev foretaget fra Bund til Overflade, og ved at Prøverne blev taget med 1 Uges Mellemrum naar Svingningerne i Antallet af pelagiske Fiskeæg Aaret igennem kunnet følges. Æggene af følgende Fisk er indbefattet i Undersøgelsen: Torsk, Rødspætte, Skrubbe, Ising, Haaising, Makrel, Brisling og Ansjos. Undersøgelsen har omfattet ialt ca. 30.000 Æg og giver saaledes et godt Indblik i Gydningstiderne. Middelantal af Æg af de forskellige Arter i Aarets forskellige Maaneder er vist hos de undersøgte Fiskearter i Fig. 1—3.

Hos Torsken begynder Gydningen i Slutningen af December (se Fig. 4). I Kattegat finder den kraftigste Gydning Sted i Januar, Februar og Marts, i Storebælt i Februar—Marts. I Begyndelsen af April hører Gydningen næsten op og kun faa Individer gyder i Maj eller Juni. Undersøgelsen tyder paa, at Torsken under Gydningen fortrinsvis opholder sig i Springlaget, d. v. s. et Vandlag hvor Temperaturfaldet nedefter er særlig brat (se Fig. 5).

Rødspættens Gydning falder paa samme Tid som Torskens, men ophører dog lidt tidligere. Senere end April er der ikke fundet Rødspætteæg i Planktonprøverne.

Skrubben begynder at gyde i Februar, og den egentlige Gydningstid er Marts, April og Maj (Fig. 7). Der synes i det sydlige Kattegat og Bælthavet at være 2 Bestande af Skrubber; den ene gyder tidligt i de dybe Render, mens den anden gyder noget senere paa Grundene og nærmere Kysten. I Aar med særlig lave Temperaturer om Vinteren falder Gydningen senere end ellers.

Isingen. Ved Halskov Rev gyder Isingen i April—Maj. Ved Schultz Grund finder den kraftigste Gydning Sted i Maj og ved Anholt Knob ikke før i Juni (Fig. 9).

Skønt Haaisingen er meget almindelig i det nordlige Kattegat, er der kun fundet faa Æg (Fig. 10), hvilket muligvis skyldes, at de store, men skrøbelige Æg ødelægges i Planktonnettet. Gydningen finder hovedsagelig Sted i Marts.

Makrellen gyder først i Juni og Juli (Fig. 11). Gydningen finder Sted i Skagerak og det nordligere Kattegat. Der er ikke fundet Æg af Makrel ved Halskov Rev, kun faa ved Schultz Grund, mens der ved Anholt Knob fandtes Makrelæg i store Mængder.

Brislingens Gydepladser ligger ikke nær ved de Fyrskibe, hvorfra Planktonprøver er blevet taget. En Gydeplads findes i Skagerak og strækker sig ind i Oslo Fjord og ned mod Anholt. Æg er fundet fra Midten af April til Midten af August, den største Mængde i April—Maj. 19 Æg fandtes ved Anholt Knob, kun 1 ved Halskov Rev og ingen ved Schultz Grund.

Ansjosens Æg er ikke tidligere fundet i de indre Farvande. I 1938, 40 og 41 fandtes i Juni og Juli nogle faa Æg ved Anholt Knob (ialt 18) og Schultz Grund (ialt 6).

DANSK TEKST TIL TABELLER OG FIGURER

Tab. 1. Middelantal af Æg pr. Træk af de forskellige Fisk i Aarets Maaneder. A: Anholt Knob (ialt 8.160 Æg), B: Schultz Grund (ialt 9.257 Æg) og C: Halskov Rev (ialt 11.634 Æg).

Tab. 2—4. Middelantal af Æg af Torsk (cod), Rødspætte (plaice), Skrubbe (flounder), Ising (dab), Haaising (long rough dab) og Makrel (mackerel) i de forskellige Gydeperioder 1929—42 ved de 3 Fyrskibe.

Fig. 1—3. Middelantal af Æg af de forskellige Arter pr. Træk med Hensen Net i 1929—41 ved hvert af de 3 Fyrskibe.

Fig. 4. Middelantal af Torskeæg i hver Gydemaaned (1929—41) ved de 3 Fyrskibe.

Fig. 5. Nr. 1—5 (til venstre) viser Vandets Temperatur (°°C) fra Overflade til Bund (0—25 m) i Aarets 4 første Maaneder. Jo mere vandret Temperaturkurven forløber, desto kraftigere er Springlaget i den paagældende Vanddybde. Paa Enkeltfigurerne er Hovedgydemaaneden for Torsken angivet i Parentes. Det ses, at den stærkeste Gydning falder sammen med det kraftigste Springlag. Den samme Forbindelse mellem kraftigt Springlag og omfattende Gydning er vist til højre fra Schultz Grund for alle Aarene 1930—39. Den fint optrukne Kurve viser Ægmængden, den stiplede Kurve den største Temperaturvariation pr. 5 m i Vandsøjlen.

Fig. 6. Middelantal af Skrubbe (F) og Ising (D) taget i Aaletog pr. $^1/_2$ Time i 1930—39. Det første Tal angiver Antallet af kønsmodne Fisk (over 3 Aar gamle); Tal i () Antal af Fisk ialt (baade Yngel og kønsmodne). En Sammenligning med Procentmængden af Æg af disse to Fisk (Side 12) viser god Overensstemmelse mellem Ægmængden og Mængden af kønsmodne Fisk.

Fig. 7. Middelantal af Æg pr. Træk af Skrubbe pr. Gydemaaned ved de 3 Fyrskibe.

Fig. 8. Sammenligning mellem Mængden af Skrubbeæg pr. Træk (fuldt optrukket Kurve) og Temperatur af Bundvandet (stiplet Kurve) ved de 3 Fyrskibe.

Fig. 9. Middelantal af Æg pr. Træk af Ising pr. Gydemaaned ved de 3 Fyrskibe.

Fig. 10. Middelantal af Æg pr. Træk af Haaising i de forskellige Gydemaaneder ved de 3 Fyrskibe.

Fig. 11. Middelantal af Æg pr. Træk af Makrel i de forskellige Gydemaaneder ved de 3 Fyrskibe.

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